COMPUTER METHODS IN BIOMECHANICS AND BIOMEDICAL ENGINEERING
2020, VOL. 23, NO. S1, S61–S62
https://doi.org/10.1080/10255842.2020.1812160

A preliminary study of stability in elite and novice 10 meter air pistol shooters

D. Chadefaux[a,b], L. Valdes-Tamayo[c], R. Moreno Flores[d], Y. Poulet[c], G. Herrera Altamira[c], S. Hybois[c], M. Coursimault[d], C. Sauret[c], V. Attali[e,f] and P. Thoreux[a,g]

[a]Université Sorbonne Paris Nord, Institut de Biomécanique Humaine Georges Charpak, IBHGC, Arts et Métiers Institute of Technology, Paris, France; [b]Département STAPS, Université Sorbonne Paris Nord, Bobigny, France; [c]Arts et Métiers Institute of Technology, Institut de Biomécanique Humaine Georges Charpak, IBHGC, Université Sorbonne Paris Nord, Bobigny, France; [d]Fédération Française de Tir, Paris, France; [e]Sorbonne Université, INSERM, UMRS1158 Neurophysiologie Respiratoire Expérimentale et Clinique, Paris, France; [f]AP-HP, Groupe Hospitalier Pitié-Salpêtrière Charles Foix, Paris, France; [g]Hôpital Avicenne, Université Paris 13, Sorbonne Paris-Cité, AP-HP, Bobigny, France

1. Introduction

Numerous processes are involved in 10 meter air pistol performance such as physiological (Tremayne and Barry 2001), sensorimotor (Cheng et al. 2017), or psychological (Baeck et al. 2012). From a biomechanical point of view, the posture stability has been investigated through the athlete's center of pressure (CoP) (Ko et al. 2017) as well as the upper-limb motion (Kevin et al. 2003). A high stability, reflected by a low CoP excursion and velocity, has been related to a high performance (Ko et al. 2017). To understand how to maximize the shooter's stability, several postural features have been discussed. For instance, (Hawkins and Sefton 2011) pointed out that the higher the stance width, the higher the CoP excursion and velocity, and the poorer the shoot performance. Under this framework, a detailed description of the CoP/Posture relationship may be noteworthy to understand shoot performance. For this purpose, although most studies focused on the whole-body CoP, we hypothesize that getting more insight into the CoP evolution under each foot may be valuable to improve performance. The objective of the present study is therefore to compare the CoP under each foot for elite and novice shooters.

2. Methods

2.1. Experimental procedure

Thirteen participants, all right-handed, were involved in this study in line with the ethical agreements (2019_A00836_51). Participants were grouped according to their level: three Elite participants from the French team, and ten Novice participants. Prior to the experiment, the Novice participants received a training at the National Institute of Sport, Expertise, and Performance (INSEP). An optoelectronic shooting system (SCATT Electronics, Moscow, Russia) was used to simulate the shots. To avoid fatigue, Elite and Novice participants performed a series of ten and eight shots, respectively. Elite participants used their own pistol while a same pistol was used by the Novice participants. For each shot, ground reaction forces were measured under each foot with two force plates (OR6 BP600600, AMTI, USA, 1000 Hz). Simultaneously, a microphone was used to detect shots and synchronize the force platform signals along with the shot performance.

2.2. Descriptors computation

The SCATT system provided information regarding the shot (results, aiming time, and trace length). The CoP under each foot was obtained through force plates and the origin was chosen at each foot's heel. The CoP displacement was normalized by the foot length and width for the antero-posterior (AP) and the mediolateral (ML) components, respectively. Finally, the amplitude A_{COP} along the AP and ML directions was computed. Further, the percent of forces applied under each foot with respect to the total forces applied to the ground was computed and is referred to as F_{ad}. Regarding the low number of Elite participants, descriptors were averaged for each Elite participant separately, while they were averaged for entire the Novice group. Consequently, the followings will describe trends and not objective results.

Table 1. Averaged shot descriptors.

	Shot results	Aiming time (s)	Trace length (mm)
Elite 1	8.9 (1.0)	17.7 (2.8)	184 (47)
Elite 2	8.8 (1.0)	10.3 (2.2)	125 (15)
Elite 3	8.8 (0.9)	4.1 (1.0)	196 (27)
Novice	5.1 (2.6)	3.4 (1.8)	452 (122)

3. Results and discussion

3.1. Shoot performance

As expected, performances were better for the Elite than the Novice participants (Table 1). Although the aiming time was shorter for the Novice participants, the length of the pistol trace on the target was more than twice as the Elite participants' ones. These results suggest more patience combined with a higher pistol stability for the Elite than the Novice participants.

3.2. Postural stability

Figure 1(a) illustrates that F_{ad} was mostly concentrated under the right foot, especially for the two first Elite participants. This observation is likely to be related to the pistol which is held in the right hand. Figure 1(b) indicates that A_{COP} was always lower than 5% and 10% of the foot dimension for the Elite and Novice participants, respectively. This result is in accordance with (Ko et al. 2017) who indicated a higher CoP motion for the Novice than the Elite shooters. Interestingly, although it is commonly stated that the CoP motion is higher along the AP than the ML direction (Ko et al. 2017), Figure 1(b) revealed two different behaviours depending on the foot. For the right foot, i.e., the pistol side, A_{COP} was indeed higher along the AP than the ML direction. Conversely, for the left foot, A_{COP} was similar along the two directions. This result may suggest an asymmetric control of the posture, most probably induced by the need of stability on the pistol side.

4. Conclusions

This study presented preliminary outcomes regarding stability in 10 meter air pistol shooters with respect to their level. Beyond the expected differences in terms of performance and stability, this investigation suggested an asymmetric control of the posture for both groups. It confirmed the interest of studying each feet separately through the CoP under each of them. This study will eventually lead to specific recommendations regarding muscular strengthening and proprioception.

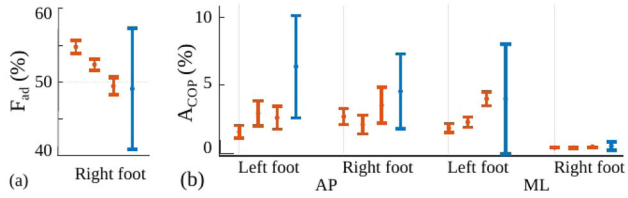

Figure 1. F_{ad} (a) and A_{COP} (b) estimated during the aiming phase. Orange and blue data represent elite and novice participants.

Acknowledgements

The authors would like to thank the French ministry of sports for funding this project, and the participants.

References

Baeck JS, Kim YT, Seo JH, Ryeom HK, Lee J, Choi SM, Woo M, Kim W, Kim JG, Chang Y. 2012. Brain activation patterns of motor imagery reflect plastic changes associated with intensive shooting training. Behav Brain Res. 234(1):26–32.

Cheng MY, Wang KP, Hung CL, Tu YL, Huang CJ, Koester D, Schack T, Hung TM. 2017. Higher power of sensorimotor rhythm is associated with better performance in skilled air-pistol shooters. Psychol Spor Exerc. 32:47–53.

Hawkins RN, Sefton JM. 2011. Effects of stance width on performance and postural stability in national-standard pistol shooters. J. Sport Sci. 29(13):1381–1387.

Kevin AB, Best RJ, Wrigley TV. 2003. Inter- and intra-individual analysis in elite sport: pistol shooting. J. Appl. Biomech. 19(1):28–38.

Ko JH, Han DW, Newell KM. 2017. Skill level constrains the coordination of posture and upper-limb movement in a pistol-aiming task. Hum Mov Sci. 55:255–263.

Tremayne P, Barry RJ. 2001. Elite pistol shooters: physiological patterning of best vs. worst shots. Int J Psychophysiol. 41(1):19–29.

KEYWORDS Posture; center of pressure; performance; 10 meter air pistol shoot

delphine.chadefaux@univ-paris13.fr